

WHAT IS CLAIMED IS:

1. Apparatus comprising

a plurality of droplet ejection devices, each said droplet ejection device including

5 a fluid chamber having a volume and an ejection nozzle,
an electrically actuated displacement device that moves between a displaced position and an undisplaced position to change said volume of said chamber as a capacitance associated with the electrically actuated displacement device changes in charge between an actuated condition and an unactuated condition, and

10 a first switch that has a first input connected to an electric source terminal, a first output connected to said electrically actuated displacement device, and a first control signal input to determine whether said first input is connected to or disconnected from said first output, and

an electric source that is connected to distribute an electrical signal to said first inputs of said plurality of droplet ejection devices, and

15 a controller that provides respective charge control signals to respective said first control signal inputs to control the extent of change in charge on respective said capacitances by the time that the respective said first switch connects said electrical signal to the respective said electrically actuated displacement device.

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2. The apparatus of claim 1 wherein said electrically actuated displacement device moves between a displaced position and an undisplaced position as a capacitance associated with the electrically actuated displacement device changes between a charged, actuated condition and an uncharged, unactuated condition, and

25 wherein said controller that provides respective charge control signals to respective said first control signal inputs to control the extent of charge placed on respective said capacitances by the time that the respective said first switch connects said electrical signal to the respective said electrically actuated displacement device.

30 3. The apparatus of claim 2

wherein each said droplet ejection device also includes a second switch that has a second input connected to a discharging electrical terminal, a second output connected to said electrically actuated displacement device, and a second control signal input to determine whether said second input is connected to or disconnected from said second output, and

5 wherein said controller provides respective discharge control signals to respective said second control signal inputs to control discharge of the charge on said respective capacitances.

4. The apparatus of claim 1 wherein each said droplet ejection device comprises a
10 first resistance between said electric source and said electrically actuated displacement device.

5. The apparatus of claim 3 wherein each said droplet ejection device comprises a
15 second resistance between said discharging electrical terminal and said electrically actuated displacement device.

6. The apparatus of claim 3 wherein each said droplet ejection device has a first
resistance that is between said electrical source and said electrically actuated displacement
device and is external of an electrical path from said electrically actuated displacement
20 device to said second switch, and further comprising a second resistance that is included in
the electrical path from said electrically actuated device to said discharging electrical
terminal.

7. The apparatus of claim 3 wherein a single resistance is used to charge and
25 discharge a respective capacitance.

8. The apparatus of claim 1 wherein a plurality of resistors, voltages and switches are
connected to each said electrically actuated displacement device and controlled by said
controller to change the charge on said capacitance.

9. The apparatus of claim 3 wherein said discharging electrical terminal is at ground.

10. The apparatus of claim 1 wherein said electrical signal is a controlled voltage signal.

5 11. The apparatus of claim 1 wherein said electrical signal is a controlled current signal.

12. The apparatus of claim 1 wherein said electrical signal is a constant current.

10 13. Apparatus comprising
a plurality of droplet ejection devices, each said droplet ejection device including
a fluid chamber having a volume and an ejection nozzle,
an electrically actuated displacement device that moves between a displaced position
and an undisplaced position to change said volume of said chamber as a capacitance
15 associated with the electrically actuated displacement device changes between a charged,
actuated condition and an uncharged, unactuated condition, and
a first switch that has a first input connected to a voltage source terminal, a first
output connected to said electrically actuated displacement device, and a first control signal
input to determine whether said first input is connected to or disconnected from said first
20 output, and
a voltage source that is connected to distribute a constant voltage electrical signal to
said first inputs of said plurality of droplet ejection devices, and
a controller that provides respective charge control signals to respective said first
control signal inputs to control the extent of charge placed on respective said capacitances by
25 the time that the respective said first switch connects said electrical signal to the respective
said electrically actuated displacement device.

14. The apparatus of claim 13 wherein said first control signal terminates the
connection of said constant voltage to said electrically actuated displacement device when
30 the charge on said electrically actuated displacement device is at a predetermined value
which is less than said constant voltage.

15. The apparatus of claim 13 wherein each said droplet ejection device also includes a second switch that has a second input connected to a discharging electrical terminal, a second output connected to said electrically actuated displacement device, and a second control signal input to determine whether said second input is connected to or disconnected from said second output, and wherein said controller provides respective discharge control signals to respective said second control signal inputs to control discharge of the charge on said respective capacitances.

16. The apparatus of claim 1 or 13 wherein electrically actuated displacement device is a piezoelectric actuator.

17. The apparatus of claim 1 or 13 wherein said first control signals are controlled to provide uniform droplet volumes or velocities from said plurality of droplet ejection devices.

18. The apparatus of claim 1 or 13 wherein said first control signals are controlled to provide predetermined different drop volumes or velocities from different droplet ejection devices so as to provide gray scale control.

19. The apparatus of claim 3 or 15 wherein said first and second control signals are controlled to provide predetermined different drop volumes or velocities from different droplet ejection devices so as to provide gray scale control.

20. The apparatus of claim 3 or 15 wherein said first and second control signals are controlled to connect said electrical signal to respective said electrically actuated displacement devices for respective predetermined times.

21. The apparatus of claim 1 or 13 wherein respective said first control signals are controlled to connect said electrical signal to respective said electrically actuated displacement devices until respective said electrically actuated displacement devices achieve respective predetermined charge voltages.

22. The apparatus of claim 1 or 13 wherein said first control signals are controlled to provide a voltage that is insufficient to eject a droplet, but is sufficient to move a meniscus of a liquid at an ejection nozzle of said droplet ejection device.

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23. The apparatus of claim 3 or 15 wherein said first and second control signals are controlled to provide a voltage that is insufficient to eject a droplet, but is sufficient to move a meniscus of a liquid at an ejection nozzle of said droplet ejection device.

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24. The apparatus of claim 1 or 13 wherein said first control signals are controlled to inject noise into images being printed so as to break up possible print patterns and banding.

25. The apparatus of claim 3 or 15 wherein said first and second control signals are controlled to inject noise into images being printed so as to break up possible print patterns and banding.

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26. The apparatus of claim 3 or 15 wherein said first and second control signals are controlled to vary the amplitude of charge as well as the length of time of charge on said electrically actuated displacement device for the first droplet out of a droplet ejection device so as to match subsequent droplets.

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27. The apparatus of claim 1 or 13 wherein said apparatus is an inkjet print head.

28. The apparatus of claim 1 or 13 wherein said controller includes a field programmable gate array on a circuit board mounted to a monolithic body in which said pumping chambers are formed.

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29. The apparatus of claim 1 or 13 wherein said controller controls said first switch as a function of the frequency of droplet ejection to reduce variation in drop volume as a function of frequency.

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